

Chapter 8—Conservation of Energy

MULTIPLE CHOICE

1. A single conservative force $F_x = (6.0x - 12) \text{ N}$ (x is in m) acts on a particle moving along the x axis. The potential energy associated with this force is assigned a value of $+20 \text{ J}$ at $x = 0$. What is the potential energy at $x = 3.0 \text{ m}$?

a. $+11 \text{ J}$
 b. $+29 \text{ J}$
 c. $+9.0 \text{ J}$
 d. -9.0 J
 e. $+20 \text{ J}$

conservative force $F_x = -\frac{du}{dx}$, $-du = F dx$
 $\int_{u_i}^{u_f} du = \int_0^3 F dx$; $u_i - u_f = \int_0^3 (6x - 12) dx = 3x^2 - 12x \Big|_0^3 = 27 - 36 = -9 \text{ J}$
 $u_f = u_i + 9 = 20 + 9 = 29 \text{ J}$

ANS: B PTS: 2 DIF: Average

2. As a particle moves along the x axis it is acted upon by a single conservative force given by $F_x = (20 - 4.0x) \text{ N}$ where x is in m. The potential energy associated with this force has the value $+30 \text{ J}$ at the origin ($x = 0$). What is the value of the potential energy at $x = 4.0 \text{ m}$?

a. -48 J
 b. $+78 \text{ J}$
 c. -18 J
 d. $+48 \text{ J}$
 e. $+80 \text{ J}$

$F_x = -\frac{du}{dx}$, $\int_{u_i}^{u_f} du = \int_0^4 F dx$, $u_i - u_f = 20x - 2x^2 \Big|_0^4 = 48 \text{ J}$
 $u_f = u_i - 48 = 30 - 48 = -18 \text{ J}$

ANS: C PTS: 2 DIF: Average

3. A 0.40-kg particle moves under the influence of a single conservative force. At point A where the particle has a speed of 10 m/s , the potential energy associated with the conservative force is $+40 \text{ J}$. As the particle moves from A to B, the force does $+25 \text{ J}$ of work on the particle. What is the value of the potential energy at point B?

a. $+65 \text{ J}$
 b. $+15 \text{ J}$
 c. $+35 \text{ J}$
 d. $+45 \text{ J}$
 e. -40 J

conservative force
 $w = -\Delta u = u_i - u_f$
 $u_f = u_i - w = 40 \text{ J} - 25 \text{ J} = 15 \text{ J}$

ANS: B PTS: 2 DIF: Average

4. As a 1.0-kg object moves from point A to point B, it is acted upon by a single conservative force which does -40 J of work during this motion. At point A the speed of the particle is 6.0 m/s and the potential energy associated with the force is $+50 \text{ J}$. What is the potential energy at point B?

a. $+72 \text{ J}$
 b. $+10 \text{ J}$
 c. $+90 \text{ J}$
 d. $+28 \text{ J}$
 e. $+68 \text{ J}$

~~$w = -\Delta u = u_i - u_f$~~
 ~~$u_f = u_i - w = 50 - (-40) = 90 \text{ J}$~~
 $w = -\Delta u = u_i - u_f$
 $u_f = u_i - w = 50 - (-40) = 90 \text{ J}$

ANS: C PTS: 2 DIF: Average

5. A 12-kg block on a horizontal frictionless surface is attached to a light spring (force constant $= 0.80 \text{ kN/m}$). The block is initially at rest at its equilibrium position when a force (magnitude $P = 80 \text{ N}$) acting parallel to the surface is applied to the block, as shown. What is the speed of the block when it is 13 cm from its equilibrium position?

$\Sigma W = W_p + W_s = \Delta K$
 $80 \times 13 \times 10^{-2} + \frac{1}{2} k x_i^2 - \frac{1}{2} k x_f^2 = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$
 $10.4 - \frac{1}{2} (0.8 \times 10^3) (13 \times 10^{-2})^2 = \frac{1}{2} (12) v_f^2 - 0$
 $v_f = 0.774 \text{ m/s}$

- a) 0.78 m/s
- b. 0.81 m/s
- c. 0.71 m/s
- d. 0.58 m/s
- e. 0.64 m/s

ANS: A PTS: 2 DIF: Average

6. A 7.0-kg block on a horizontal frictionless surface is attached to a light spring (force constant = 1.2 kN/m). The block is initially at rest at its equilibrium position when a force of magnitude P acting parallel to the surface is applied to the block, as shown. When the block is 8.0 cm from the equilibrium position, it has a speed of 0.80 m/s. How much work is done on the block by the force P as the block moves the 8.0 cm?

$\Sigma W = \Delta K, W_p + W_s = \frac{1}{2} m (v_f^2 - v_i^2)$
 $W_p + \frac{1}{2} k x_i^2 - \frac{1}{2} k x_f^2 = \frac{1}{2} m ((0.8)^2 - 0)$
 $W_p = \frac{1}{2} m (0.8)^2 + \frac{1}{2} (1.2 \times 10^3) (8 \times 10^{-2})^2$
 $W_p = 6.08 \text{ J}$

- a. 7.4 J
- b. 5.4 J
- c. 6.1 J
- d. 6.7 J
- e. 4.9 J

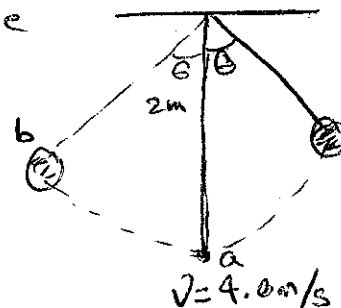
ANS: C PTS: 2 DIF: Average

7. A 0.60-kg object is suspended from the ceiling at the end of a 2.0-m string. When pulled to the side and released, it has a speed of 4.0 m/s at the lowest point of its path. What maximum angle does the string make with the vertical as the object swings up?

a. 61° Gravitational force → Conservative
 b. 54° $(\frac{1}{2} m v^2 + mgh)_a = (\frac{1}{2} m v^2 + mgh)_b$
 c. 69° $(\frac{1}{2} m v^2)_a = (mgh)_b \rightarrow h = 0.816 \text{ m}$
 d. 77°
 e. 47°

ANS: B PTS: 3 DIF: Challenging

$\cos \theta = \frac{2 - 0.816}{2}, \theta = 53.77$



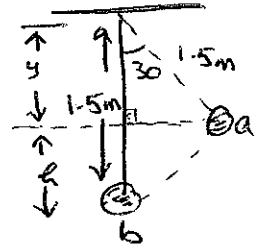
8. A pendulum is made by letting a 2.0-kg object swing at the end of a string that has a length of 1.5 m. The maximum angle the string makes with the vertical as the pendulum swings is 30° . What is the speed of the object at the the lowest point in its trajectory?

- a. 2.0 m/s
b. 2.2 m/s
c. 2.5 m/s
d. 2.7 m/s
e. 3.1 m/s

$$\cos 30 = \frac{y}{1.5}; y = 1.5 \cos 30 = 1.5 (0.866) \text{ m}$$

$$h = 1.5 - y = 1.5 - 1.5 (0.866) = 0.25 \text{ m}$$

$$(mgh)_a = \left(\frac{1}{2}mv^2\right)_b \quad v = \sqrt{2gh} = 1.97 \text{ m/s}$$



ANS: A PTS: 2 DIF: Average

9. A 2.0-kg mass swings at the end of a light string (length = 3.0 m). Its speed at the lowest point on its circular path is 6.0 m/s. What is its kinetic energy at an instant when the string makes an angle of 50° with the vertical?

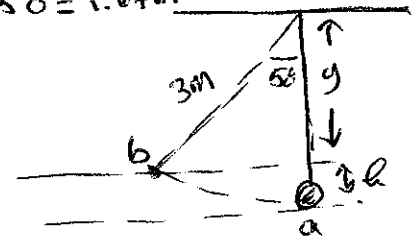
- a. 21 J
b. 15 J
c. 28 J
d. 36 J
e. 23 J

$$\cos 50 = \frac{3-h}{3}, \quad h = 3 - 3 \cos 50 = 1.07 \text{ m}$$

$$\left(\frac{1}{2}mv^2\right)_a = (mgh + \frac{1}{2}mv^2)_b$$

$$\frac{1}{2}(36) = 2(9.8)(1.07) + K_b$$

$$K_b = 15 \text{ J}$$



ANS: B PTS: 3 DIF: Challenging

10. A 2.5-kg object suspended from the ceiling by a string that has a length of 2.5 m is released from rest with the string 40° below the horizontal position. What is the tension in the string at the instant when the object passes through its lowest position?

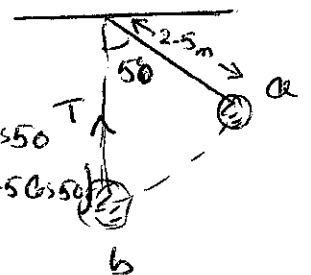
- a. 11 N
b. 25 N
c. 42 N
d. 18 N
e. 32 N

$$T = \frac{mv^2}{R} + mg \cos \theta = \frac{mv^2}{R} + mg$$

$$\left(\frac{1}{2}mv^2\right)_a + (mgh)_a = \frac{1}{2}mv^2_b$$

$$mgh = \frac{1}{2}mv^2, \quad mv^2 = 2mgh, \quad h = 2.5 - 2.5 \cos 50$$

$$mv^2 = 2mg(2.5 - 2.5 \cos 50)$$



ANS: C PTS: 3 DIF: Challenging

$$T = \frac{mv^2}{2.5} + mg = 42 \text{ N}$$

11. A certain pendulum consists of a 1.5-kg mass swinging at the end of a string (length = 2.0 m). At the lowest point in the swing the tension in the string is equal to 20 N. To what maximum height above this lowest point will the mass rise during its oscillation?

- a. 77 cm
b. 50 cm
c. 63 cm
d. 36 cm
e. 95 cm

$$T = \frac{mv^2}{R} + mg; \quad 20 = \frac{1.5v^2}{2} + 1.5(9.8); \quad v^2 = 7.066 \text{ m}^2/\text{s}^2$$

$$\frac{1}{2}mv^2 = mgh; \quad h = \frac{v^2}{2g} = \frac{7.066}{2(9.8)} = 0.36 \text{ m}$$

ANS: D PTS: 3 DIF: Challenging

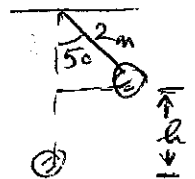
12. A 0.80-kg object tied to the end of a 2.0-m string swings as a pendulum. At the lowest point of its swing, the object has a kinetic energy of 10 J. Determine the speed of the object at the instant when the string makes an angle of 50° with the vertical.

- a. 5.6 m/s
b. 4.4 m/s
c. 3.3 m/s
d. 5.0 m/s
e. 6.1 m/s

$$\frac{1}{2}mv_a^2 + 0 = \frac{1}{2}mv_b^2 + mgh_b$$

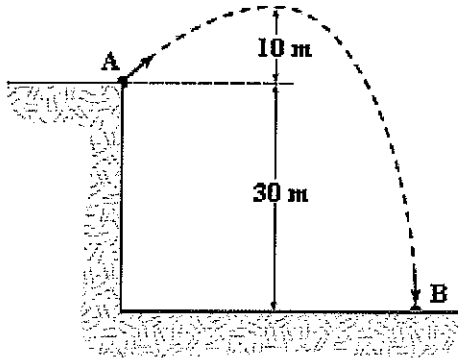
$$10 = \frac{1}{2}(0.8)v_b^2 + 0.8(9.8)(2 - 2 \cos 50)$$

$$v_b = 3.31 \text{ m/s}$$



ANS: C PTS: 2 DIF: Average

13. A 0.04-kg ball is thrown from the top of a 30-m tall building (point A) at an unknown angle above the horizontal. As shown in the figure, the ball attains a maximum height of 10 m above the top of the building before striking the ground at point B. If air resistance is negligible, what is the value of the kinetic energy of the ball at B minus the kinetic energy of the ball at A ($K_B - K_A$)?



$$\begin{aligned}
 W &= \Delta K \\
 W &= mgh = \Delta K \\
 &= 0.04(9.8)(30) = \Delta K \\
 &= 11.76 \text{ J} = \Delta K = K_B - K_A
 \end{aligned}$$

- a. 12 J
 b. -12 J
 c. 20 J
 d. -20 J
 e. 32 J

ANS: A

PTS: 2

DIF: Average

14. A 1.2-kg mass is projected from ground level with a velocity of 30 m/s at some unknown angle above the horizontal. A short time after being projected, the mass barely clears a 16-m tall fence. Disregard air resistance and assume the ground is level. What is the kinetic energy of the mass as it clears the fence?

- a. 0.35 kJ
 b. 0.73 kJ
 c. 0.40 kJ
 d. 0.68 kJ
 e. 0.19 kJ

$$\begin{aligned}
 \frac{1}{2} m v_0^2 &= \frac{1}{2} m v^2 + mgh = K + mgh \\
 K &= \frac{1}{2} m v_0^2 - mgh = \frac{1}{2} (1.2)(30)^2 - 1.2(9.8)(16) \\
 &= 351 \text{ J}
 \end{aligned}$$

ANS: A

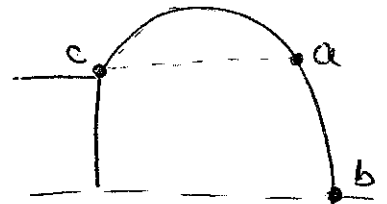
PTS: 2

DIF: Average

15. A 2.0-kg mass is projected from the edge of the top of a 20-m tall building with a velocity of 24 m/s at some unknown angle above the horizontal. Disregard air resistance and assume the ground is level. What is the kinetic energy of the mass just before it strikes the ground?

- a. 0.18 kJ
 b. 0.97 kJ
 c. 0.89 kJ
 d. 0.26 kJ
 e. 0.40 kJ

$$\begin{aligned}
 \left(\frac{1}{2} m v_0^2 + mgh \right)_a &= \frac{1}{2} m v_b^2 \\
 &= K_b \\
 \frac{1}{2} (2)(24)^2 + 2(9.8)(20) &= K_b \\
 958 \text{ J} &= K_b
 \end{aligned}$$

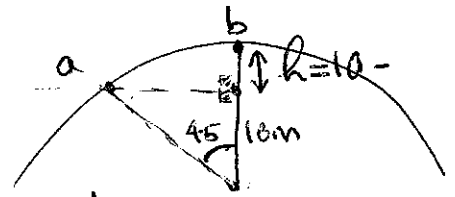
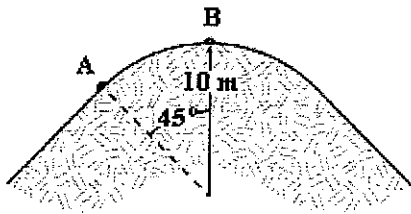


ANS: B

PTS: 2

DIF: Average

16. A skier weighing 0.70 kN goes over a frictionless circular hill as shown. If the skier's speed at point A is 9.2 m/s, what is his speed at the top of the hill (point B)?



- a. 3.1 m/s
- b. 6.2 m/s
- c. 5.2 m/s
- d. 4.1 m/s
- e. 6.5 m/s

ANS: C

PTS: 2

DIF: Average

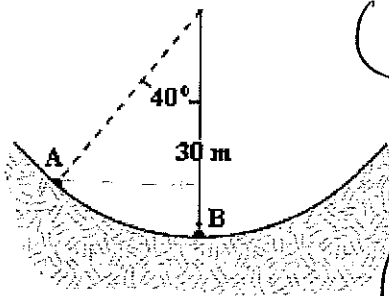
$$\left(\frac{mv^2}{2} + mgh\right)_a = \left(\frac{mv^2}{2} + mgh\right)_b$$

$$\frac{1}{2}(0.7)(9.2)^2 - mg(h_b - h_a) = \frac{1}{2}mv_b^2$$

$$\frac{1}{2}(0.7)(9.2)^2 - 0.7(9.8)(10 - 10\cos 45) = \frac{1}{2}(0.7)v_b^2$$

$$v_b = 5.21 \text{ m/s}$$

17. A skier weighing 0.80 kN comes down a frictionless ski run that is circular ($R = 30 \text{ m}$) at the bottom, as shown. If her speed is 12 m/s at point A, what is her speed at the bottom of the hill (point B)?



- a. 17 m/s
- b. 19 m/s
- c. 18 m/s
- d. 20 m/s
- e. 12 m/s

ANS: A

PTS: 2

DIF: Average

$$\left(\frac{mv^2}{2} + mgh\right)_a = \left(\frac{mv^2}{2} + mgh\right)_b$$

$$\left(\frac{mv^2}{2}\right)_b = \left(\frac{mv^2}{2}\right)_a + mg(h_a - h_b)$$

$$m = \frac{0.8 \times 10^3}{9.8} = 81.6 \text{ kg}, \quad h_a - h_b = 30 - 30\cos 40$$

$$v = 16.77 \text{ m/s}$$

18. A spring ($k = 600 \text{ N/m}$) is placed in a vertical position with its lower end supported by a horizontal surface. The upper end is depressed 20 cm, and a 4.0-kg block is placed on top of the depressed spring. The system is then released from rest. How far above the point of release will the block rise?

- a. 46 cm
- b. 36 cm
- c. 41 cm
- d. 31 cm
- e. 20 cm

ANS: D

PTS: 2

DIF: Average

$$mgh = \frac{1}{2}kx^2$$

$$h = \frac{1}{2} \frac{(600)(20 \times 10^{-2})^2}{4(9.8)} = 0.306 \text{ m}$$

19. A spring ($k = 200 \text{ N/m}$) is suspended with its upper end supported from a ceiling. With the spring hanging in its equilibrium configuration, an object (mass = 2.0 kg) is attached to the lower end and released from rest. What is the speed of the object after it has fallen 4.0 cm?

- a. 90 cm/s
- b. 79 cm/s
- c. 96 cm/s
- d. 83 cm/s

$$\left(mgh = \frac{1}{2}kx^2\right)_a = \left(\frac{1}{2}mv^2 + mgh\right)_b$$

$$\frac{1}{2}mv^2 = mg(h_a - h_b) - \frac{1}{2}kx^2$$

$$\frac{1}{2}(2)v^2 = 2(9.8)(4 \times 10^{-2}) - \frac{1}{2}(200)(16 \times 10^{-4})$$

$$v = 78.9 \text{ cm/s}$$

e. 57 cm/s

ANS: B

PTS: 2

DIF: Average

20. A 2.0-kg block sliding on a horizontal frictionless surface is attached to one end of a horizontal spring ($k = 200 \text{ N/m}$) which has its other end fixed. If the block has a speed of 4.0 m/s as it passes through the equilibrium position, what is its speed when it is 20 cm from the equilibrium position?

- a. 2.6 m/s
 b. 3.1 m/s
 c. 3.5 m/s
 d. 1.9 m/s
 e. 2.3 m/s

$$\frac{1}{2}kx_i^2 - \frac{1}{2}kx_f^2 = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

$$\frac{1}{2}mv_f^2 = \frac{1}{2}mv_i^2 - \frac{1}{2}kx_f^2 = \frac{1}{2}(2)(16) - \frac{1}{2}(200)(0.20)^2$$

ANS: C

PTS: 2

DIF: Average

$$v_f = 3.5 \text{ m/s}$$

21. A block (mass = 4.0 kg) sliding on a horizontal frictionless surface is attached to one end of a horizontal spring ($k = 100 \text{ N/m}$) which has its other end fixed. If the maximum distance the block slides from the equilibrium position is equal to 20 cm, what is the speed of the block at an instant when it is a distance of 16 cm from the equilibrium position?

- a. 71 cm/s
 b. 60 cm/s
 c. 80 cm/s
 d. 87 cm/s
 e. 57 cm/s

$$\frac{1}{2}kx_i^2 - \frac{1}{2}kx_f^2 = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

$$\frac{1}{2}(100)(0.20)^2 - \frac{1}{2}(100)(0.16)^2 = \frac{1}{2}mv_f^2 - 0$$

$$v_f = 0.6 \text{ m/s}$$

ANS: B

PTS: 2

DIF: Average

22. A 1.0-kg block is released from rest at the top of a frictionless incline that makes an angle of 37° with the horizontal. An unknown distance down the incline from the point of release, there is a spring with $k = 200 \text{ N/m}$. It is observed that the mass is brought momentarily to rest after compressing the spring 0.20 m. How far does the mass slide from the point of release until it is brought momentarily to rest?

- a. 0.98 m
 b. 0.68 m
 c. 0.82 m
 d. 0.55 m
 e. 0.20 m

for the spring: $\frac{1}{2}kx_i^2 - \frac{1}{2}kx_f^2 = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$

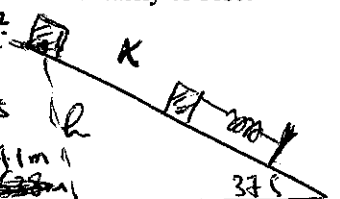
$$0 - \frac{1}{2}(200)(0.2)^2 = 0 - \frac{1}{2}(1)v_i^2, v_i = 2.82 \text{ m/s}$$

v_i is the mass velocity before striking

use spring: $mgh = \frac{1}{2}kx_i^2$

$$l = \frac{v_i^2}{2g} = \frac{(2.82)^2}{2(9.8)} = 0.41 \text{ m}$$

$x = l / \sin 37 = 0.68 \text{ m}$



ANS: B

PTS: 2

DIF: Average

23. A 20-kg mass is fastened to a light spring ($k = 380 \text{ N/m}$) that passes over a pulley as shown. The pulley is frictionless, and the mass is released from rest when the spring is unstretched. After the mass has dropped 0.40 m, what is its speed?

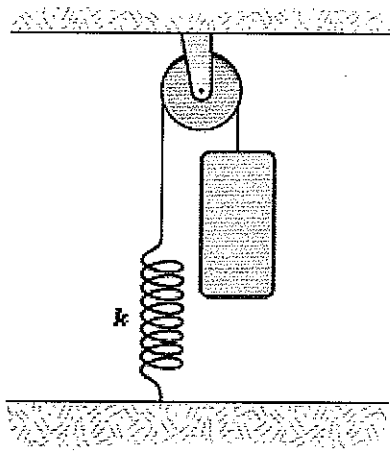
$$\sum W = \Delta K$$

$$W_s + W_g = \Delta K$$

$$\frac{1}{2}kx_i^2 - \frac{1}{2}kx_f^2 + mgh = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

$$-\frac{1}{2}(380)(0.4)^2 + 20(9.8)(0.4) = \frac{1}{2}(20)v_f^2$$

$$v_f = 2.19 \text{ m/s}$$



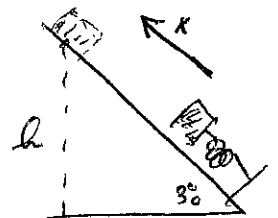
- a. 2.2 m/s
 b. 2.5 m/s
 c. 1.9 m/s
 d. 1.5 m/s
 e. 3.6 m/s

ANS: A PTS: 2 DIF: Average

24. A spring ($k = 600 \text{ N/m}$) is at the bottom of a frictionless plane that makes an angle of 30° with the horizontal. The upper end of the spring is depressed 0.10 m , and a 2.0-kg block is placed against the depressed spring. The system is then released from rest. What is the kinetic energy of the block at the instant it has traveled 0.10 m and the spring has returned to its uncompressed length?

a. 2.0 J
 b. 1.8 J
 c. 2.2 J
 d. 1.6 J
 e. 1.0 J

$\sum W = \Delta K$, $W_s + W_g = \frac{mv_f^2}{2} - \frac{mv_i^2}{2}$
 $\frac{1}{2} kx_i^2 - \frac{1}{2} kx_f^2 - mgh = \frac{mv_f^2}{2} - \frac{mv_i^2}{2}$; $h = x \sin \theta$
 $\frac{1}{2} (600)(0.1)^2 - 2(9.8)(0.1 \sin 30) = K_f$
 $2.0 \text{ J} = K_f$

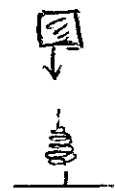


ANS: A PTS: 2 DIF: Average

25. A spring ($k = 600 \text{ N/m}$) is placed in a vertical position with its lower end supported by a horizontal surface. A 2.0-kg block that is initially 0.40 m above the upper end of the spring is dropped from rest onto the spring. What is the kinetic energy of the block at the instant it has fallen 0.50 m (compressing the spring 0.10 m)?

a. 5.3 J
 b. 6.8 J
 c. 6.3 J
 d. 5.8 J
 e. 6.5 J

$\sum W = \Delta K$; $W_s + W_g = \Delta K = K_f - K_i$
 $\frac{1}{2} kx_i^2 - \frac{1}{2} kx_f^2 + mgh = K_f$
 $-\frac{1}{2} k(0.1)^2 + 2(9.8)(0.5) = K_f$
 $6.8 \text{ J} = K_f$



ANS: B PTS: 2 DIF: Average

26. A 2.0-kg block slides down a fixed, rough curved track. The block has a speed of 5.0 m/s after its height above a horizontal surface has decreased by 1.8 m . Assume the block starts from rest. What is the change in mechanical energy of the block caused by the force of friction during this descent?

a. -14 J
 b. -12 J
 c. -10 J
 d. -16 J
 e. -25 J

$\sum W = \Delta K$, $W_f + W_g = \Delta K$, $W_f - \Delta U = \Delta K$
 $W_f = \Delta K + \Delta U$, $W_f = \Delta(K + U)$
 $= \Delta E_{\text{mech}}$
 $= \frac{1}{2} mv_f^2 - \frac{1}{2} mv_i^2 + mg(h_f - h_i)$
 $= \frac{1}{2} (2)(25) + 2(9.8)(-1.8)$
 $= -10.2 \text{ J}$

ANS: C

PTS: 2

DIF: Average

27. A 1.5-kg block sliding on a rough horizontal surface is attached to one end of a horizontal spring ($k = 200 \text{ N/m}$) which has its other end fixed. If this system is displaced 20 cm horizontally from the equilibrium position and released from rest, the block first reaches the equilibrium position with a speed of 2.0 m/s. What is the coefficient of kinetic friction between the block and the horizontal surface on which it slides?

- a. 0.34
b. 0.24
c. 0.13
d. 0.44
e. 0.17

$$\sum W = \Delta K, \quad W_s + W_f = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$$

$$\frac{1}{2} k x_i^2 - \frac{1}{2} k x_f^2 + f \cdot d = \frac{1}{2} m v_f^2; \quad f = \mu N = \mu mg, \quad \vec{f} \cdot \vec{d} = f d \cos 180^\circ$$

$$\frac{1}{2} (200) (20 \times 10^{-2})^2 - \mu (1.5) (9.8) (0.2) = \frac{1}{2} (1.5) (4)$$

$$\mu = 0.34$$

ANS: A

PTS: 2

DIF: Average

28. A 0.75-kg sphere is released from rest and is moving 5.0 m/s after falling 2.0 m in a viscous medium. What is the change in mechanical energy caused by the force the viscous medium exerts on the sphere during this descent?

- a. -6.1 J
b. -4.6 J
c. -5.3 J
d. -6.8 J
e. -2.7 J

$$\sum W = \Delta E_{\text{mech}}$$

$$W_{\text{viscous}} = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2 + mg (h_f - h_i)$$

$$= \frac{1}{2} (0.75) (25) + 0.75 (9.8) (-2)$$

$$= -5.32 \text{ J}$$

ANS: C

PTS: 2

DIF: Average

29. A 12-kg projectile is launched with an initial vertical speed of 20 m/s. It rises to a maximum height of 18 m above the launch point. What is the change in mechanical energy caused by the dissipative (air) resistive force on the projectile during this ascent?

- a. -0.64 kJ
b. -0.40 kJ
c. -0.52 kJ
d. -0.28 kJ
e. -0.76 kJ

$$\sum W = \Delta E_{\text{mech}}$$

$$\frac{1}{2} m v_i^2 = mg (h_f - h_i) + W_{\text{diss}}$$

$$W_{\text{diss}} = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2 + mg (h_f - h_i)$$

$$= -\frac{1}{2} (12) (20)^2 + 12 (9.8) (18 - 0)$$

$$= -283.2 \text{ J}$$

ANS: D

PTS: 2

DIF: Average

30. A 10-kg object is dropped from rest. After falling a distance of 50 m, it has a speed of 26 m/s. What is the change in mechanical energy caused by the dissipative (air) resistive force on the object during this descent?

- a. -1.3 kJ
b. -1.5 kJ
c. -1.8 kJ
d. -2.0 kJ
e. -2.3 kJ

$$\sum W = \Delta E_{\text{mech}}; \quad W_{\text{air}} = \Delta E_{\text{mech}}$$

$$W_{\text{air}} = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2 + mg (h_f - h_i)$$

$$= \frac{1}{2} (10) (26)^2 + 10 (9.8) (-50) = -1520 \text{ J}$$

ANS: B

PTS: 2

DIF: Average

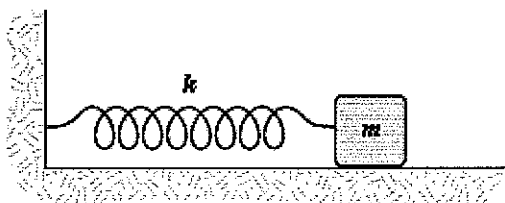
31. The block shown is released from rest when the spring is stretched a distance d . If $k = 50 \text{ N/m}$, $m = 0.50 \text{ kg}$, $d = 10 \text{ cm}$, and the coefficient of kinetic friction between the block and the horizontal surface is equal to 0.25, determine the speed of the block when it first passes through the position for which the spring is unstretched.

$$\sum W = \Delta K; \quad W_s + W_f = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2 = \frac{1}{2} m v_f^2$$

$$\frac{1}{2} k x_i^2 - \frac{1}{2} k x_f^2 + (f \cdot d) = \frac{1}{2} m v_f^2$$

$$\frac{1}{2} (50) (0.1)^2 + \mu N d \cos 180^\circ = \frac{1}{2} (0.5) v_f^2; \quad N = mg$$

$$\frac{1}{2} (50) (0.1)^2 - 0.25 (0.5) (9.8) (0.1) = \frac{1}{2} (0.5) v_f^2, \quad v_f = 0.71 \text{ m/s}$$



- a. 92 cm/s
- b. 61 cm/s
- c. 71 cm/s
- d. 82 cm/s
- e. 53 cm/s

ANS: C PTS: 3 DIF: Challenging

32. A 2.0-kg block sliding on a rough horizontal surface is attached to one end of a horizontal spring ($k = 250 \text{ N/m}$) which has its other end fixed. The block passes through the equilibrium position with a speed of 2.6 m/s and first comes to rest at a displacement of 0.20 m from equilibrium. What is the coefficient of kinetic friction between the block and the horizontal surface?

- a. 0.32
- b. 0.45
- c. 0.58
- d. 0.19
- e. 0.26

$$\begin{aligned} \sum W &= \Delta K = \frac{mv_f^2}{2} - \frac{mv_i^2}{2} = \frac{2}{2} (0 - (2.6)^2) \\ W_s + W_f &= -(2.6)^2 ; \frac{1}{2} k(x_i^2 - x_f^2) + \mu mgd \cos 180 = -(2.6)^2 \\ \frac{1}{2} (250) (0 - (0.2)^2) - \mu (2)(9.8)(0.2) &= -(2.6)^2 \\ \mu &= 0.448 \end{aligned}$$

ANS: B PTS: 2 DIF: Average

33. In a given frictionless displacement of a particle, its kinetic energy increases by 25 J while its potential energy decreases by 10 J. Determine the work of the nonconservative forces acting on the particle during this displacement.

- a. -15 J
- b. +35 J
- c. +15 J
- d. -35 J
- e. +55 J

$$\begin{aligned} \sum W &= \Delta E_{\text{mech}} = \Delta(K + U) \\ &= \Delta K + \Delta U \\ &= 25 - 10 = 15 \text{ J} \end{aligned}$$

ANS: C PTS: 1 DIF: Easy

34. A particle is acted upon by only two forces, one conservative and one nonconservative and neither being a force of friction, as it moves from point A to point B. The kinetic energies of the particle at points A and B are equal if

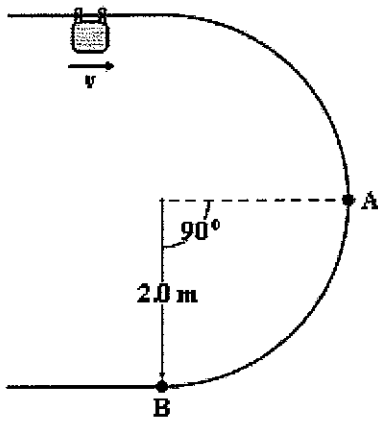
- a. the sum of the works of the two forces is zero.
- b. the work of the conservative force is equal to the work of the nonconservative force.
- c. the work of the conservative force is zero.
- d. the work of the nonconservative force is zero.
- e. None of the above.

$$\begin{aligned} \sum W &= \Delta K, \quad W_{\text{con}} + W_{\text{non}} = \Delta K \\ &\text{if } \Delta K = 0 \\ &\text{then } W_{\text{con}} + W_{\text{non}} = 0 \end{aligned}$$

ANS: A PTS: 1 DIF: Easy

35. A 1.2-kg mass is projected down a rough circular track (radius = 2.0 m) as shown. The speed of the mass at point A is 3.2 m/s, and at point B, it is 6.0 m/s. What is the change in mechanical energy done on the system between A and B by the force of friction?

$$\begin{aligned} \sum W &= \Delta E_{\text{mech}} = \frac{1}{2} m (v_b^2 - v_a^2) + mg(h_b - h_a) \\ &= \frac{1}{2} (1.2) (36 - (3.2)^2) + 1.2(9.8)(-2) \\ &= -8.06 \text{ J} \end{aligned}$$



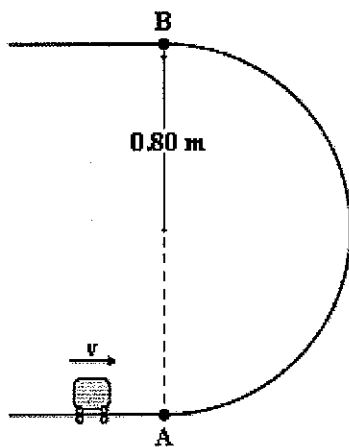
- a. -8.9 J
- b. -7.3 J
- c. -8.1 J
- d. -6.6 J
- e. -24 J

ANS: C

PTS: 2

DIF: Average

36. A 1.2-kg mass is projected up a rough circular track (radius = 0.80 m) as shown. The speed of the mass at point A is 8.4 m/s, and at point B, it is 5.6 m/s. What is the change in mechanical energy between A and B caused by the force of friction?



$$\begin{aligned}
 \Sigma W &= \Delta E_{\text{mech}} \\
 &= \frac{1}{2} m (v_b^2 - v_a^2) + mg (h_b - h_a) \\
 &= \frac{1}{2} (1.2) ((5.6)^2 - (8.4)^2) + 1.2 (9.8) (1.6) \\
 &= -4.70 \text{ J}
 \end{aligned}$$

- a. -2.7 J
- b. -8.8 J
- c. -4.7 J
- d. -6.7 J
- e. -19 J

ANS: C

PTS: 2

DIF: Average

37. A 3.0-kg mass is dropped from the edge of a 50-m tall building with an initial speed of zero. The mass strikes the ground with a downward velocity of 25 m/s. Find the change in mechanical energy of the mass caused by air resistance between the point where it is dropped and the point where it strikes the ground?

- a. -0.46 kJ
- b. -0.53 kJ

$$\begin{aligned}
 \Sigma W &= \Delta E_{\text{mech}} \\
 W_{\text{air}} &= \frac{1}{2} m (v_f^2 - v_i^2) + mg (h_f - h_i) \\
 &= \frac{1}{2} (3) ((25)^2 - 0) + 3 (9.8) (-50) \\
 &= -532.5 \text{ J}
 \end{aligned}$$

- c. -0.61 kJ
- d. -0.38 kJ
- e. -0.81 kJ

ANS: B

PTS: 2

DIF: Average

38. A 2.0-kg mass is projected vertically upward from ground level with an initial speed of 30 m/s. The mass rises to a maximum height of 35 m above ground level. What is the change in mechanical energy of the mass caused by air resistance between the point of projection and the point of maximum height?

- (a) -0.21 kJ
- b. -0.47 kJ
- c. -0.40 kJ
- d. -0.34 kJ
- e. -0.69 kJ

$$\sum W = \Delta E_{\text{mech}}; \quad W_{\text{air}} = \frac{m}{2}(v_f^2 - v_i^2) + mg(h_f - h_i)$$

non-conservative

$$W_{\text{air}} = \frac{2}{2}((0)^2 - (30)^2) + 2(9.8)(35)$$

$$= -214 \text{ J}$$

ANS: A

PTS: 2

DIF: Average

39. A 25-kg block on a horizontal surface is attached to a light spring (force constant = 8.0 kN/m). The block is pulled 10 cm to the right from its equilibrium position and released from rest. When the block has moved 2.0 cm toward its equilibrium position, its kinetic energy is 12 J. What is the change in mechanical energy caused by the frictional force on the block as it moves the 2.0 cm?

- a. -4.0 J
- b. -3.5 J
- (c) -2.4 J
- d. -2.9 J
- e. -15 J

$$\sum W = \Delta K; \quad W_s + W_f = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$$

$$\frac{1}{2} K x_i^2 - \frac{1}{2} K x_f^2 + W_f = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$$

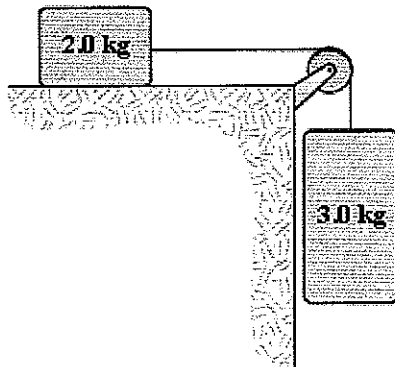
$$W_f = -2.4 \text{ J}$$

ANS: C

PTS: 2

DIF: Average

40. The two masses in the figure are released from rest. After the 3.0-kg mass has fallen 1.5 m, it is moving with a speed of 3.8 m/s. What is the change in mechanical energy done on the system during this time interval by the frictional force on the 2.0 kg mass?



- a. -12 J
- b. -17 J
- c. -20 J
- d. -8.0 J
- e. -28 J

ANS: D

PTS: 2

DIF: Average

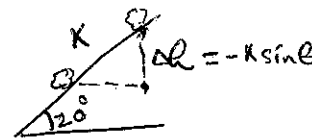
41. A 2.0-kg block is projected down a plane that makes an angle of 20° with the horizontal with an initial kinetic energy of 2.0 J. If the coefficient of kinetic friction between the block and plane is 0.40, how far will the block slide down the plane before coming to rest?

- a. 3.0 m
b. 1.8 m
c. 0.30 m
d. 1.0 m
e. 1.3 m

$$\sum W = \Delta E_{\text{mech}}; \quad W_f = \Delta E_{\text{mech}}$$

$$-\mu mg \cos \theta x = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2 + mg(h_f - h_i)$$

$$-\mu mg \cos \theta x = -2 + mg(x \sin \theta)$$



ANS: A

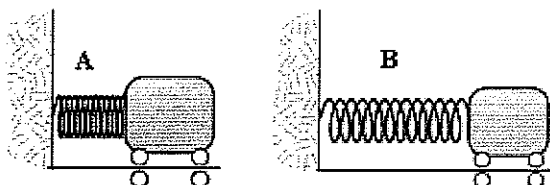
PTS: 3

DIF: Challenging

Solve for x :

$$x = \frac{2}{mg(\mu \cos \theta - \sin \theta)} = 3.0 \text{ m}$$

42. A large spring is used to stop the cars after they come down the last hill of a roller coaster. The cars start at rest at the top of the hill and are caught by a mechanism at the instant their velocities at the bottom are zero. Compare the compression of the spring, x_A , for a fully loaded car with that, x_B , for a lightly loaded car when $m_A = 2m_B$.



- a. $x_A = \frac{1}{2} x_B$
b. $x_A = x_B$
c. $x_A = \sqrt{2} x_B$
d. $x_A = 2 x_B$
e. $x_A = 4 x_B$

$$\frac{1}{2} k x_A^2 = \frac{1}{2} (2m_B) v_A^2 \rightarrow (1)$$

$$\frac{1}{2} k x_B^2 = \frac{1}{2} m_B v_B^2 \rightarrow (2)$$

$$\frac{x_A^2}{x_B^2} = 2, \quad x_A = \sqrt{2} x_B$$

ANS: C

PTS: 2

DIF: Average

43. A small lead sphere of mass m is hung from a spring of spring constant k . The gravitational potential energy of the system equals zero at the equilibrium position of the spring before the weight is attached. The total mechanical energy of the system when the mass is hanging at rest is

- a. $-kx^2$
b. $-\frac{1}{2} kx^2$
c. 0.
d. $+\frac{1}{2} kx^2$
e. $+kx^2$

$$W_s = \frac{1}{2} k x_i^2 - \frac{1}{2} k x_f^2 = -\frac{1}{2} k x^2$$

ANS: B

PTS: 1

DIF: Easy

44. Cubical blocks of mass m and side l are piled up in a vertical column. The total gravitational potential energy of a column of three blocks is

- a. $\frac{5}{2} mgl$
b. $3mgl$
c. $\frac{9}{2} mgl$
d. $6mgl$
e. $9mgl$

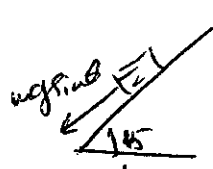
ANS: C

PTS: 2

DIF: Average

45. An all-terrain vehicle of 2 000 kg mass moves up a 15.0° slope at a constant velocity of 6.00 m/s. The rate of change of gravitational potential energy with time is
- 5.25 kW.
 - 24.8 kW.
 - 30.4 kW.**
 - 118 kW.
 - 439 kW.

$$P = \vec{F} \cdot \vec{v} = mg \sin \theta (v) \cos(180^\circ)$$

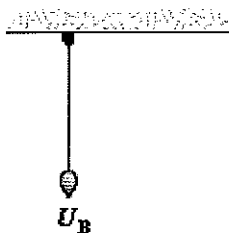
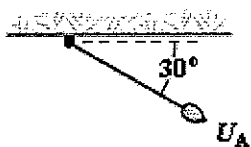
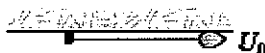
$$= 2000(9.8) \sin(15)(6)(-1) = -30.4 \text{ kW}$$


ANS: C

PTS: 2

DIF: Average

46. A pendulum bob has potential energy U_0 when held taut in a horizontal position. The bob falls until it is 30° away from the horizontal position, when it has potential energy U_A . It continues to fall until the string is vertical, when it has potential energy U_B . Compare its potential energies at O, A, and B.



- $U_0 = U_A = U_B$.
- $U_A - U_B = 2U_0$.
- $U_A - U_B = U_0 - U_A$.**
- $U_0 = U_B = 2U_A$.
- $U_0 - U_A = 2(U_A - U_B)$.

ANS: C

PTS: 1

DIF: Easy

47. A spring with spring constant $k = 800 \text{ N/m}$ is compressed 12 cm from its equilibrium position. A spring with spring constant $k = 400 \text{ N/m}$ has the same elastic potential energy as the first spring when its extension is
- 0.060 m.
 - 0.085 m.
 - 0.12 m.
 - 0.17 m.**
 - 0.24 m.

$$U = \frac{kx^2}{2}, \quad 800(12)^2 = 400x^2$$

$$x = 16.9 \text{ cm}$$

ANS: D

PTS: 2

DIF: Average

48. A spring with spring constant $k = 800 \text{ N/m}$ is extended 12 cm from its equilibrium position. A spring with 6.0 cm extension from equilibrium will have the same potential energy as the first spring if its spring constant is

a. 200 N/m.
 b. 400 N/m.
 c. 800 N/m.
 d. 1 600 N/m.
 e. 3 200 N/m.

$$U_1 = U_2, \quad k_1 x_1^2 = k_2 x_2^2, \quad 800(12)^2 = k_2(36)$$

$$k_2 = 3.2 \text{ kN/m}$$

ANS: E PTS: 2 DIF: Average

49. A champion athlete can produce one horsepower (746 W) for a short period of time. If a 70-kg athlete were to bicycle to the summit of a 500-m high mountain while expending power at this rate, she would have used at least _____ J of energy.

a. 746
 b. 3.43×10^5
 c. 3.73×10^5
 d. 7.46×10^5
 e. 2.61×10^7

$$PE = mgh = 70(9.8)(500)$$

$$= 3.43 \times 10^5 \text{ J}$$

ANS: B PTS: 2 DIF: Average

50. A champion athlete can produce one horsepower (746 W) for a short period of time. If a 70-kg athlete were to bicycle to the summit of a 500-m high mountain while expending power at this rate, she would reach the summit in _____ seconds.

a. 1
 b. 460
 c. 500
 d. 1 000
 e. 35 000

$$P = \frac{W}{t}, \quad t = \frac{PE}{P} = \frac{3.43 \times 10^5}{746}$$

$$= 459.7 \text{ s}$$

ANS: B PTS: 2 DIF: Average

51. A champion athlete can produce one horsepower (746 W) for a short period of time. The number of 16 cm high steps a 70 kg athlete could ascend in one minute while expending one horsepower is

a. 4.
 b. 7.
 c. 65.
 d. 408.
 e. 4 567.

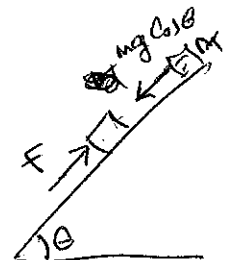
$$P = \frac{mgh}{T}, \quad h = \frac{PT}{mg} = \frac{746(60)}{70(9.8)} \text{ m} = 65.24 \text{ m}$$

$$\# \text{ steps} = \frac{65.24}{0.16} = 407.75$$

ANS: D PTS: 2 DIF: Average

52. Objects A and B, of mass M and $2M$ respectively, are each pushed a distance d straight up an inclined plane by a force F parallel to the plane. The coefficient of kinetic friction between each mass and the plane has the same value μ_k . At the highest point,

a. $K_A = Fd = K_B$.
 b. $K_A = (F - \mu_k Mg \cos\theta)d$; $K_B = (F - 2\mu_k Mg \cos\theta)d$.
 c. $K_A = (F - Mg \sin\theta)d$; $K_B = (F - 2Mg \sin\theta)d$.
 d. $K_A = (F - Mg \sin\theta - \mu_k Mg \cos\theta)d$; $K_B = (F - Mg \sin\theta - \mu_k Mg \cos\theta)d$.
 e. $K_A = (F - Mg \sin\theta - \mu_k Mg \cos\theta)d$; $K_B = (F - 2Mg \sin\theta - 2\mu_k Mg \cos\theta)d$.



ANS: E PTS: 2 DIF: Average

53. As an object moves from point A to point B only two forces act on it: one force is nonconservative and does -30 J of work, the other force is conservative and does $+50\text{ J}$ of work. Between A and B,
- a. the kinetic energy of object increases, mechanical energy decreases.
 - b. the kinetic energy of object decreases, mechanical energy decreases.
 - c. the kinetic energy of object decreases, mechanical energy increases.
 - d. the kinetic energy of object increases, mechanical energy increases.
 - e. None of the above.

ANS: A PTS: 1 DIF: Easy

54. As an object moves from point A to point B only two forces act on it: one force is conservative and does -70 J of work, the other force is nonconservative and does $+50\text{ J}$ of work. Between A and B,
- a. the kinetic energy of object increases, mechanical energy increases.
 - b. the kinetic energy of object decreases, mechanical energy increases.
 - c. the kinetic energy of object decreases, mechanical energy decreases.
 - d. the kinetic energy of object increases, mechanical energy decreases.
 - e. None of the above.

ANS: B PTS: 1 DIF: Easy

55. An astronaut tosses a ball out in space where gravitational forces may be neglected. What will happen to the ball?
- a. It will stop as soon as the force the astronaut gave it is used up.
 - b. It will stop when the energy the astronaut gave it runs out.
 - c. It will stop after a short time because there is no gravity to keep it moving.
 - d. It will move in a circle like a boomerang.
 - e. It will be slowed down very gradually by collisions with molecules in space.

ANS: E PTS: 1 DIF: Easy

56. Which of the following is a conservative force? (All refer to a car on a slope.)
- a. The force you exert on the car pushing it uphill.
 - b. The force exerted by rain drops falling on the car.
 - c. The frictional force of the road on the car.
 - d. The gravitational force acting on the car.
 - e. The force you exert on the car (pushing it uphill) after it starts to slide downhill.

ANS: D PTS: 1 DIF: Easy

57. For a force to be a conservative force, when applied to a single test body
- a. it must have the same value at all points in space.
 - b. it must have the same direction at all points in space.
 - c. it must be parallel to a displacement in any direction.
 - d. equal work must be done in equal displacements.
 - e. no net work must be done for motion in closed paths.

ANS: E PTS: 1 DIF: Easy

58. The force a spring exerts on a body is a conservative force because
- a. a spring always exerts a force opposite to the displacement of the body.
 - b. a spring always exerts a force parallel to the displacement of the body.
 - c. the work a spring does on a body is equal for compressions and extensions of equal magnitude.
 - d. the work a spring does on a body is equal and opposite for compressions and extensions of equal magnitude.

- e) the net work a spring does on a body is zero when the body returns to its initial position.

ANS: E PTS: 1 DIF: Easy

59. Identical masses m are attached to identical springs of spring constant k suspended from the ceiling. With both masses hanging in their equilibrium positions, mass A is pulled down 10 cm and released while mass B is pushed up 10 cm and released. Which statement is correct?
- Mass A will travel a smaller distance to its highest point than mass B will travel to its lowest point.
 - Mass A will travel a greater distance to its highest point than mass B will travel to its lowest point.
 - Masses A and B will travel equal distances between their highest and lowest points.
 - More work was done on mass A by the extending force than on mass B by the compressing force.
 - The total work done on mass A by the extending force was equal to the total work done on mass B by the compressing force.

ANS: C PTS: 3 DIF: Challenging

60. Objects A and B, of mass M and $2M$ respectively, are each pushed a distance d straight up an inclined plane by a force F parallel to the plane. The coefficient of kinetic friction between each mass and the plane has the same value μ_k . At the highest point,
- $K_A > K_B$.
 - $K_A = K_B$.
 - $K_A < K_B$.
 - The work done by F on A is greater than the work done by F on B.
 - The work done by F on A is less than the work done by F on B.

ANS: A PTS: 2 DIF: Average

61. The equation below describes a physical situation:

$$\begin{aligned} & \frac{1}{2} (1.70 \text{ kg}) \left(3.30 \frac{\text{m}}{\text{s}} \right)^2 + (1.70 \text{ kg}) \left(9.80 \frac{\text{m}}{\text{s}^2} \right) (2.35 \text{ m}) \sin 30^\circ \\ &= \frac{1}{2} (1.70 \text{ kg}) \left(4.60 \frac{\text{m}}{\text{s}} \right)^2 + 0.320 (1.70 \text{ kg}) \left(9.80 \frac{\text{m}}{\text{s}^2} \right) (2.35 \text{ m}) \cos 30^\circ \end{aligned}$$

Which description best fits the equation?

- A 1.70 kg block slows down while sliding down a frictionless plane inclined at a 30° angle.
- A 1.70 kg block slows down while sliding down a plane with $\mu_k = 0.320$, with the plane inclined at a 30° angle.
- A 1.70 kg block speeds up while sliding up a frictionless plane inclined at a 30° angle.
- A 1.70 kg block speeds up while sliding down a plane with $\mu_k = 0.320$, with the plane inclined at a 30° angle.
- A 1.70 kg block slides over the top of an inclined plane and then descends on the other side. Both planes, inclined at a 30° angle, have $\mu_k = 0.320$.

ANS: D PTS: 2 DIF: Average

62. A spring with spring constant 800 N/m compressed 0.200 m is released and projects a 0.800 kg mass along a frictionless surface. The mass reaches a surface area where $\mu_k = 0.400$ and comes to a stop. The following student solution contains at least one error. What is the error?

$$\frac{1}{2} \left(800 \frac{\text{N}}{\text{m}} \right) (0.200 \text{ m})^2 = \frac{1}{2} (0.500 \text{ kg}) \left(8.00 \frac{\text{m}}{\text{s}} \right)^2 + 0.400 (0.500 \text{ kg}) \left(9.80 \frac{\text{m}}{\text{s}^2} \right) (8.16 \text{ m})$$

- The elastic potential energy is equal only to the kinetic energy on the right, and is never equal to the internal thermal energy.
- The elastic potential energy is equal only to the internal thermal energy on the right, and is never equal to the kinetic energy.
- The elastic potential energy is equal to either the kinetic energy or the internal thermal energy on the right, but not to their sum, depending on the part of the problem being done.
- Elastic potential energy cannot end up as internal energy change caused by friction.
- Change in mechanical energy by friction cannot end up as elastic potential energy.

ANS: C PTS: 1 DIF: Easy

63. The solution to a problem is the equation below. Which description best fits this solution?

$$\begin{aligned} & \frac{1}{2} \left(500 \frac{\text{N}}{\text{m}} \right) (0.120 \text{ m})^2 - (2.00 \text{ kg}) \left(9.80 \frac{\text{m}}{\text{s}^2} \right) (0.120 \text{ m}) \\ &= \frac{1}{2} (2.00 \text{ kg}) \left(0.824 \frac{\text{m}}{\text{s}} \right)^2 + (2.00 \text{ kg}) \left(9.80 \frac{\text{m}}{\text{s}^2} \right) (0.029 \text{ m}) \end{aligned}$$

- A vertical spring compressed 0.120 m shoots a 2.00 kg mass 2.90 cm above the equilibrium position of the spring.
- A vertical spring stretched 0.120 m shoots a 2.00 kg mass 9.10 cm above the equilibrium position of the spring.
- A vertical spring compressed 0.120 m shoots a 2.00 kg mass 12.0 cm above the equilibrium position of the spring.
- A vertical spring compressed 0.120 m shoots a 2.00 kg mass 14.9 cm above the equilibrium position of the spring.
- A 2.00 kg mass has fallen 0.820 m and compressed the upper end of a vertical spring 12.0 cm below the equilibrium position.

ANS: A PTS: 2 DIF: Average

64. As a result of friction between internal parts of an isolated system
- the total mechanical energy of the system increases.
 - the total mechanical energy of the system decreases.
 - the total mechanical energy of the system remains the same.
 - the potential energy of the system increases but the kinetic energy remains the same.
 - the kinetic energy of the system increases but the potential energy of the system remains the same.

ANS: B PTS: 1 DIF: Easy

65. A 3.50 kg block is pulled along a moving conveyor belt at a constant speed of 0.500 m/s relative to a stationary observer while the belt moves at a constant speed of 0.200 m/s in the same direction. If the coefficient of kinetic friction is 0.400, the magnitude of the mechanical energy dissipated, in J, caused by the force of friction on the block in 8.00 s is

- 5.6.
- 22.0.
- 32.9.
- 54.8.

$$\begin{aligned} P &= \mu N \cdot v = \mu m g v \\ &= 0.4 (3.5) (9.8) (0.5 - 0.2) \\ &= 4.116 \text{ W} \end{aligned}$$

$$P = \frac{E}{t}, \quad E = Pt = 4.11 (8) = 32.9 \text{ J}$$

e. 76.8.

ANS: C

PTS: 3

DIF: Challenging

66. A 3.50 kg block is pulled along a moving conveyor belt at a constant speed of 0.500 m/s relative to a stationary observer while the belt moves at a constant speed of 0.200 m/s in the opposite direction. If the coefficient of kinetic friction is 0.400, the magnitude of the mechanical energy dissipated, in J, caused by the force of friction on the block in 8.00 s is

- a. 5.6.
b. 22.0.
c. 32.9.
d. 54.8.
e. 76.8.

$$P = \mu mg v = 0.4(3.5)(9.8)(0.5 - (-0.2))$$
$$= 9.604 \text{ W}$$
$$P = \frac{E}{t} \quad E = Pt = 9.604(8) = 76.8 \text{ J}$$

ANS: E

PTS: 3

DIF: Challenging

67. Jane and Jake are looking at what happens to body 1 of mass m and body 2 of mass $2m$, initially at rest, when equal forces are applied separately to the two bodies. Jake says that equal forces applied for equal times do equal amounts of work on the two bodies. Jane says that the two forces do equal amounts of work only if the two bodies move equal distances in the direction of the forces. Which one, if either, is correct?

- a. Jake, because the speed of body 1 is half the speed of body 2, but $m_1 v_1 = m_2 v_2$.
b. Jane, because work does not depend on mass, only on force times distance.
c. Jake, because all bodies travel equal distances when equal forces are applied for equal times.
d. Jane, because it takes the same time for all bodies to travel equal distances when equal forces are involved.
e. Neither, because we can't compare the amounts of work done on bodies of different mass.

ANS: B

PTS: 2

DIF: Average

68. The same force F is applied horizontally to bodies 1, 2, 3 and 4, of masses m , $2m$, $3m$ and $4m$, initially at rest and on a frictionless surface, until each body has traveled distance d . The correct listing of the magnitudes of the velocities of the bodies, v_1 , v_2 , v_3 , and v_4 is

- a. $v_4 = \sqrt{\frac{4}{3}} v_3 = \sqrt{\frac{3}{2}} v_2 = 2v_1$.
b. $v_4 = v_2 > v_3 = v_1$.
c. $v_1 = \sqrt{2} v_2 = \sqrt{3} v_3 = 2v_4$.
d. $v_1 = 2v_2 = 3v_3 = 4v_4$.
e. $v_4 = \frac{3}{4} v_3 = \frac{2}{3} v_2 = \frac{1}{2} v_1$.

ANS: C

PTS: 3

DIF: Challenging

69. Any change of the energy of a system occurs because of

- a. energy transfer across the boundaries of the system.
b. combustion of fuels within the system.
c. radioactive decay of elements within the system.
d. all of the above.
e. only (b) and (c) above.

ANS: A

PTS: 1

DIF: Easy

70. Two masses, M_A and M_B , with $M_B = 2M_A$, are released at the same time and allowed to fall straight down. Neglect air resistance. When we compare their kinetic energies after they have fallen equal distances, we find that
- $K_B = K_A$.
 - $K_B = 2K_A$.
 - $K_B = 4K_A$.
 - $K_A = 2K_B$.
 - $K_A = 4K_B$.

ANS: B PTS: 1 DIF: Easy

71. Two masses, M_A and M_B , with $M_B = 2M_A$, are released at the same time and allowed to fall straight down. Neglect air resistance. When we compare their kinetic energies after they have fallen for equal times, we find that
- $K_B = K_A$.
 - $K_B = 2K_A$.
 - $K_B = 4K_A$.
 - $K_A = 2K_B$.
 - $K_A = 4K_B$.

ANS: B PTS: 1 DIF: Easy

72. A 6.0-kg block slides along a horizontal surface. If $\mu_k = 0.20$ for the block and surface, at what rate is the friction force changing the mechanical energy of the block at an instant when its speed is 4.0 m/s?
- 59 W
 - 47 W
 - 71 W
 - 82 W
 - +71 W

$$P = \vec{F} \cdot \vec{v} = f v \cos 180$$

$$= \mu N v \cos 180$$

$$= -\mu mg v$$

$$= -0.2(6)(9.8)(4.0) = -47 \text{ W}$$

ANS: B PTS: 2 DIF: Average

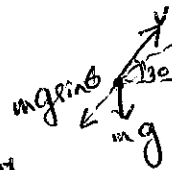
73. At what rate is the gravitational force on a 2.0-kg projectile doing work at an instant when the velocity of the projectile is 4.0 m/s directed 30° above the horizontal?
- +39 W
 - 78 W
 - 39 W
 - +78 W
 - +25 W

$$P = \vec{F} \cdot \vec{v}$$

$$= (mg \sin \theta)(v) \cos 180$$

$$= -mg \sin \theta (v)$$

$$= -2(9.8) \sin 30 (4) = -39.2 \text{ W}$$



ANS: C PTS: 2 DIF: Average

74. A 2.0-kg block slides down a plane (inclined at 40° with the horizontal) at a constant speed of 5.0 m/s. At what rate is the gravitational force on the block doing work?
- +98 W
 - +63 W
 - zero
 - +75 W
 - 75 W

$$P = \vec{F} \cdot \vec{v} = (mg \sin \theta)(v) \cos 0$$

$$= 2(9.8) \sin 40 (5)$$

$$= 63 \text{ W}$$



ANS: B PTS: 2 DIF: Average

75. The speed of a 4.0-kg object is given by $v = (2t)$ m/s, where t is in s. At what rate is the resultant force on this object doing work at $t = 1$ s?
- 48 W

$$P = \vec{F} \cdot \vec{v} = m \frac{dv}{dt} \cdot v$$

$$\frac{dv}{dt} = 2 \text{ m/s}^2$$

$$P = 4(2)(2(1)) = 16 \text{ W}$$

- b. 40 W
- c. 32 W
- d. 56 W
- e. 16 W**

ANS: E

PTS: 3

DIF: Challenging

76. A 3.0-kg block is on a frictionless horizontal surface. The block is at rest when, at $t = 0$, a force (magnitude $P = 2.0$ N) acting at an angle of 22° above the horizontal is applied to the block. At what rate is the force P doing work at $t = 2.0$ s?

- a. 2.3 W**
- b. 2.0 W
- c. 1.4 W
- d. 1.7 W
- e. 1.2 W

$$P = (P \cos \theta) v \cos(0)$$

$$= 2 \cos(22^\circ) (v)$$



const. acc: $v = v_0 + at = 0 + a(2)$; $P \cos \theta = ma$, $a = \frac{2 \cos 22}{3}$

$$v = \frac{2 \cos 22}{3} (2)$$

$$\text{then } P = 2 \cos(22) \frac{2 \cos 22}{3} (2) = 2.3 \text{ W}$$

ANS: A

PTS: 3

DIF: Challenging

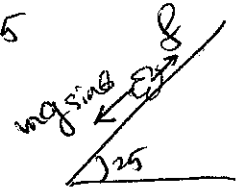
77. A 1.6-kg block slides down a plane (inclined at 25° with the horizontal) at a constant speed of 2.0 m/s. At what rate is the frictional force changing the mechanical energy of the block?

- a. +28 W
- b. +13 W
- c. -13 W**
- d. -28 W
- e. +6.5 W

$$mg \sin \theta - f = 0 \rightarrow f = mg \sin \theta = 1.6(9.8) \sin 25$$

$$P = f \cdot v = 1.6(9.8) \sin 25 (2) \cos 180$$

$$P = -13.2 \text{ W}$$



ANS: C

PTS: 2

DIF: Average

78. A 3.0-kg block is on a horizontal surface. The block is at rest when, at $t = 0$, a force (magnitude $P = 12$ N) acting parallel to the surface is applied to the block causing it to accelerate. The coefficient of kinetic friction between the block and the surface is 0.20. At what rate is the force P doing work on the block at $t = 2.0$ s?

- a. 54 W
- b. 49 W**
- c. 44 W
- d. 59 W
- e. 24 W

$$P - f_k = ma$$

$$a = \frac{P - f_k}{m} = \frac{12 - \mu mg}{m}$$

$$= \frac{12 - 0.2(3)(9.8)}{3}$$



$$v = v_0 + at = 0 + a(2)$$

$$P = \vec{P} \cdot \vec{v} = 12 \left(\frac{12 - 0.2(3)(9.8)}{3} (2) \right) = 48.96 \text{ W}$$

ANS: B

PTS: 3

DIF: Challenging

79. Starting from rest at $t = 0$, a 5.0-kg block is pulled across a horizontal surface by a constant horizontal force having a magnitude of 12 N. If the coefficient of friction between the block and the surface is 0.20, at what rate is the 12-N force doing work at $t = 5.0$ s?

- a. 0.13 kW
- b. 0.14 kW
- c. 0.12 kW
- d. 26 W**
- e. 12 W

$$F - f_k = ma$$

$$12 - \mu N = ma \quad 12 - 0.2(5)(9.8) = 5a$$

$$v = v_0 + at = 0 + \frac{12 - 0.2(5)(9.8)}{5} (5)$$

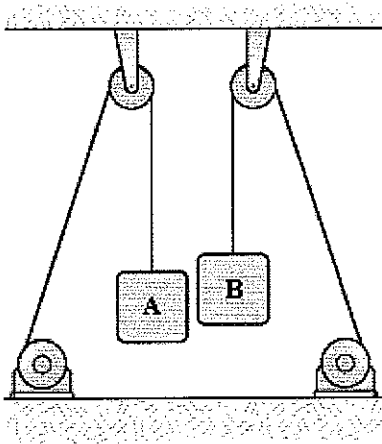
$$P = \vec{F} \cdot \vec{v} = 12 \left(\frac{12 - 0.2(5)(9.8)}{5} (5) \right) = 26 \text{ W}$$

ANS: D

PTS: 2

DIF: Average

80. Two equal masses are raised at constant velocity by ropes that run over pulleys, as shown below. Mass B is raised twice as fast as mass A. The magnitudes of the forces are F_A and F_B , while the power supplied is respectively P_A and P_B . Which statement is correct?



- a. $F_B = F_A; P_B = P_A.$
- b. $F_B = F_A; P_B = 2 P_A.$
- c. $F_B = 2 F_A; P_B = P_A.$
- d. $F_B = 2 F_A; P_B = 2 P_A.$
- e. $P_A = F_A; P_B = F_B.$

Equal forces but $v_B = 2v_A$

ANS: B PTS: 2 DIF: Average

PROBLEM

81. A rain cloud contains 2.66×10^7 kg of water vapor. How long would it take for a 2.0 kW pump to lift the same amount of water to an altitude of 2 000 m?

ANS:
8.26 years

$$\text{power} = \frac{W}{t}, 2 \times 10^3 = \frac{mgh}{t}, t = \frac{2.66 \times 10^7 (9.8) (2000)}{2 (10^3)}$$

$$= 26 \times 10^7 \text{ s} = 26 \times 10^7 / 60 \times 60 \times 24 \times 365 = 8.26 \text{ yrs}$$

PTS: 2 DIF: Average

82. A surprising demonstration involves dropping an egg from a third-floor window to land on a foam-rubber pad 2 in (5 cm) thick without breaking. If a 56-gram egg falls 12 m, and the foam pad stops the egg in 6.25 ms, by how much is the pad compressed?

ANS:
4.8 cm

PTS: 3 DIF: Challenging

83. A 70-kg high jumper leaves the ground with a vertical velocity of 6.0 m/s. How high can he jump?

ANS:
1.84 m

$$\frac{1}{2} v^2 = mgh$$

$$h = \frac{v^2}{2g} = \frac{36}{2(9.8)} = 1.836 \text{ m}$$

PTS: 2 DIF: Average

84. A simple pendulum, 2.0 m in length, is released from rest when the support string is at an angle of 25° from the vertical. What is the speed of the suspended mass at the bottom of the swing?

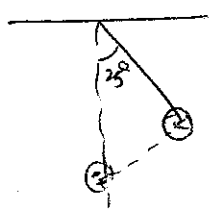
ANS:
1.9 m/s

$$mgh = \frac{1}{2} m v^2$$

$$mg(L - L \cos \theta) = \frac{1}{2} m v^2$$

$$9.8(2 - 2 \cos 25) = \frac{1}{2} v^2$$

$$v = 1.91 \text{ m/s}$$



PTS: 2

DIF: Average

85. While running, a person dissipates about 0.6 J of mechanical energy per step per kilogram of body mass. If a 60-kg person runs with a power of 70 Watts during a race, how fast is the person running? Assume a running step is 1.5 m long.

ANS:

2.92 m/s

PTS: 3

DIF: Challenging

86. When an automobile moves with constant velocity the power developed is used to overcome the frictional forces exerted by the air and the road. If the power developed in an engine is 50.0 hp, what total frictional force acts on the car at 55 mph (24.6 m/s)? One horsepower equals 746 W.

ANS:

1 520 N

PTS: 2

DIF: Average

$$P = FV$$
$$F = \frac{P}{V} = \frac{50(746) \text{ W}}{24.6 \text{ m/s}}$$
$$= 1516 \text{ N}$$